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Welding-through doweling of wood panels

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Abstract Panel products have been joined to levels satisfying the requirements of the relevant standards for metallic connector assemblies by rotation welding of beech dowels through them. The wood panels substrates such as particleboard, OSB and MDF welded to the dowels almost as well as solid timber. Welded-through dowel assemblies presented better stiffness of the test joints than similar assemblies of dowelled solid timber.

Reibschweiß-Verdübelung von Holzwerkstoffen

Zusammenfassung Mittels Reibschweißen hergestellte Verbindungen von Holzwerkstoffen mit Buchendübeln entsprechen den Anforderungen der Normen für Verbindungen mit metallischen Verbindungsmitteln. Die Holzwerkstoffe wie zum Beispiel Spanplatten, OSB- und MDF-Platten ließen sich mit Dübeln nahezu so gut wie Massivholz verschweißen. Die Reibschweiß-Dübelverbindung der Holzwerkstoffe wiesen eine höhere Steifigkeit auf als vergleichbare Massivholzverbindungen.

1 Introduction

Recently, high speed rotation-induced wood dowels welding without any adhesive has been shown to rapidly yield wood joints of considerable strength (Pizzi et al. 2004, Kanazawa et al. 2005, Ganne-Chedeville et al. 2005). The mechanism of mechanically-induced high speed rotation wood welding is due to the temperature-induced softening and flowing of some amorphous, cells-interconnecting polymer material in the structure of wood, and consequent high densification of the bonded interface (Pizzi et al. 2004, Kanazawa et al. 2005, Ganne-Chedeville et al. 2005, Stamm et al. 2005). This joining system has introduced the possibility of manufacturing wood structural joints and beams satisfying relevant structural standards through wood do-

wels welding and without the use of any adhesives. This is an extension to structural applications of the wood welding concept. It competes successfully with established wood fasteners such as nails and PVAc-bonded wood dowels.

A metallic connectors assembly submitted to a force presents a linear first part of the deformation, this being a reversible deformation. The second part of the deformation corresponds to the plastic behaviour of the steel nail. Thus, the deformation is irreversible. The curve tends then to the assembly breaking point. In Eurocode 5 (prEN 1995-1-1 2003) the assembly deformation is called service stiffness. The stiffer the assembly the greater is the necessary breaking force and the lower the plastic deformation. In conclusion, a stiff and strong assembly is an assembly where the forces are distributed more evenly for a more homogeneous strain in the material.

Welded dowel joints were then tested to check if they could be used for joining not just solid timber but also different types

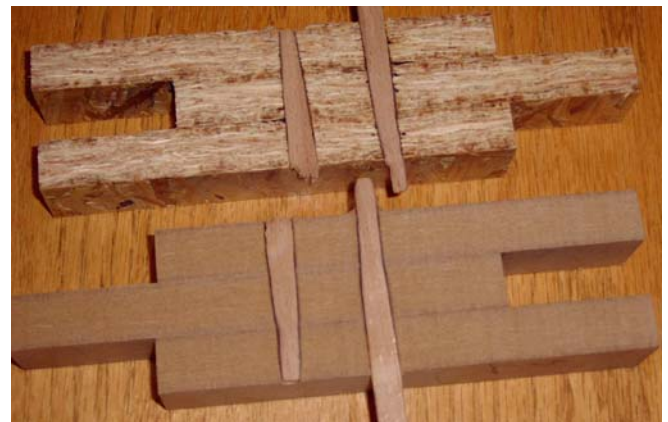


Fig. 1 Sections of examples of specimens for stiffness testing composed of OSB or MDF panels joined by two dowels welded through them. Note, the dark thin interface between dowels and substrate indicating good welding

Abb. 1 Querschnitte von Probekörpern aus OSB und MDF zur Steifigkeitsprüfung einer Reibschweiß-Verbindung mit zwei Dübeln. Hinweis: Die dunkle, dünne Fläche zwischen Dübel und Holzwerkstoff weist auf die gute Verschweißung hin

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of wood panels. For this reason, joints for structural testing of the joint stiffness and maximal welding strength of the dowel were prepared by connecting different panels with two dowels per joint according to structural European Norms (EN) testing (EN 26891 1991, EN 1380 1999). Thus, joints were prepared according to Fig. 1, joined through the three layers of different wood panels by means of two 10 mm diameter dowels according to relevant European Norm standards for testing the suitability of the assembly for structural application. Four different types of panels were used in the test: an oriented strand board (OSB), a medium density fiberboard (MDF), a particleboard, one plywood panel and beech solid timber under controlled conditions.

2 Experimental

Testing specimens of $170 \times 60 \times 18$ mm, according to European Norm EN 26891 (1991) and prEN 1995-1-1 (2003) Eurocode 5, composed of 18 mm thick OSB, MUF-bonded particleboard, UF-bonded MDF and 11-ply PF-bonded poplar plywood were prepared according to the configurations shown in Fig. 1. Fluted groove beech dowels were inserted and rotation welded through the panel assemblies at 90° within three seconds, according to conditions already reported (Pizzi et al. 2004, Kanazawa et al. 2005, Ganne-Chedeville et al. 2005) to see if any configuration was capable of a higher shear result and better stiffness. The specimens were tested according to EN 1380 (1999) and EN 383 (1993). Solid beech timber control was used and in the case of the OSB panels a steel nailed assembly having the same configuration was also tested for comparative purposes. The results obtained are shown in Table 1.

X-ray microdensitometry tests were done on the prepared joints. The equipment used consisted of an X-ray tube producing “soft rays” (low energy level) emitted through a beryllium window. These were used to produce an X-ray negative photograph of approx. 2 mm thick sample slices, conditioned at 12% moisture content, at a distance of 2.5 m from the tube. This distance is important to minimise blurring of the image on the film frame (18×24 cm) used. The usual exposure conditions were: 4 hours, 7.5 kW and 12 mA. Two calibration samples were placed on each negative photograph in order to calculate wood density values. The specimens were tested in this manner on an equipment consisting of an electric generator (INEL XRG3000), an X-ray tube (SIEMENS FK60-04 Mo, 60 kV–2.0 kW) and a KODAK negative film Industrex type M100.

3 Results and discussion

The results of the test according to European Norm EN 1380 (1999), and prEN 1995-1-1 (2003) Eurocode 5, of assemblies of different panels welded by two through dowels as shown in Fig. 1, indicate that the dowel withdrawal strength in the case of panels is of the same order of magnitude when welded through panels of different nature as it is when welded through solid timber (beech in Table 1). Only the dowel withdrawal strength in plywood is markedly lower. This is due to the much lower density of the poplar veneers industrial plywood used for the experiment in relation to the density of the other panels and of solid timber. The dowel withdrawal strength results in Table 1 mean that through-dowel connection of timber panels by welding yields performances of the welded joint as acceptable as in solid timber through-dowel welding. Of interest is that welding was good and that the line of welding of the different panels appeared to be well formed, of regular shape and of high density (Fig. 2a,b). An example for the condition of the weld-line, obtained by X-ray microdensitometry, in the case of OSB is shown in Fig. 2. Welding appears to occur as in the case

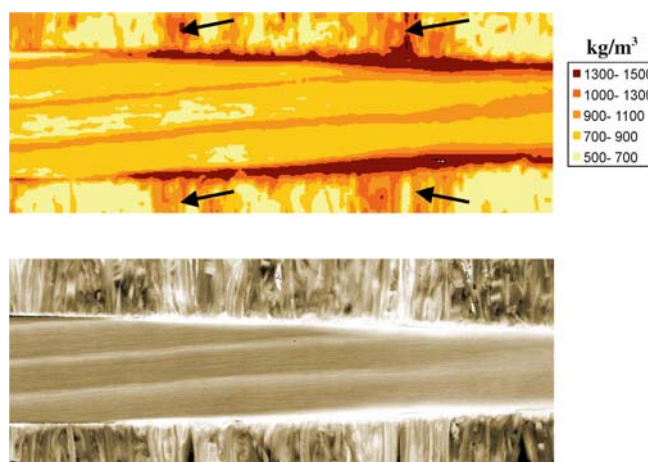


Fig. 2 a Example of a typical density map, obtained by X-ray microdensitometry, of a dowel welded through three pieces of an OSB panel. **b** X-ray picture from which the microdensitometry map in Fig. 2a has been derived
Abb. 2 a Typische, mittels Röntgen-Mikrodensitometrie bestimmte Rohdichteverteilung einer Reibschweiß-Dübelverbindung von drei OSB-Lagen
b Röntgenbild aus dem die Rohdichteverteilung in Abb. 2a bestimmt wurde

Table 1 Dowel withdrawal and test specimen stiffness average results obtained for different wood panels joined by through-weld dowels

Tabelle 1 Durchschnittliche Dübelauszugsfestigkeit und Steifigkeit der Reibschweiß-Dübelverbindung verschiedener Holzwerkstoffe

	Solid timber Beech	OSB	Particleboard	MDF	Plywood	OSB steel nailed
Dowel withdrawal						
Average strength (N)	9500	8800	8800	9000	7100	10500
Stiffness (N/mm)						
In charging	3300	5100	4000	4300	4800	3800
In discharging	3950	6600	5300	5650	6600	4950
In recharging	4200	7050	5800	6200	7100	5000

of solid timber and no interference appears to occur from the small amount of hardened adhesive used to manufacture the panel (Fig. 2), neither in the OSB panel nor in the other types of panel.

The application according to European Norm EN 26891 (1991) and prEN 1995-1-1 (2003) Eurocode 5, of a charging force on the joint, followed by force discharging and then by force charging again of the joint, allows to calculate joint stiffness during the three different phases of the test. The results obtained are shown in Table 1. The results show that stiffness is greater in all the phases of charging/discharging and recharging in the case of through-dowel welding of wood panels than in the case of solid beech timber. Particularly noteworthy are the values obtained in the case of OSB panels. It is for this reason that the stiffness of the same type of OSB joint, but fastened by steel nails was also tested (Table 1). The results show that through-welded dowel assemblies are capable, even in the stiffer assembly case such as an OSB substrate, to give better stiffness than steel-nailed assemblies of the same design.

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